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# LOW-RESPONSE-RATE CONDITIONING HISTORY AND FIXED-INTERVAL RESPONDING IN RATS

JANET R. LEFRANCOIS AND BARBARA METZGER

CONVERSE COLLEGE AND ANDERSON COLLEGE

Bar presses by one group of rats were conditioned under a differential-reinforcement-of-low-rate reinforcement schedule immediately prior to conditioning under a fixed-interval schedule. In a second group of rats, bar presses were conditioned first under a differential-reinforcement-of-low-rate schedule and then under a fixed-ratio schedule prior to conditioning under a fixed-interval schedule. Low response rates occurred under the fixed-interval schedule only when it was immediately preceded by low-rate conditioning. Otherwise, fixed-interval responding was similar to responding under the fixed-ratio schedule. This finding suggests that responses of laboratory animals are sensitive to immediate history, and, unlike human responses, are relatively insensitive to a history of low-rate conditioning when it is followed by high-rate conditioning.

*Key words:* conditioning history, fixed-interval schedule, differential-reinforcement-of-low-rate schedule, fixed-ratio schedule, lever press, rats

One of the goals of the experimental analysis of behavior has been to demonstrate that behavior is a lawful and orderly function of an organism's environment (Skinner, 1953). The environment, however, is not limited to current conditions: Behavior is a function of present contingencies only through past experience (Branch, 1987). That is, current responding reflects an interaction between control by current contingencies and past ones. Although the field of behavior analysis has focused on current contingencies that minimize the extent and duration of past experiences, of interest in the current paper is control by past contingencies.

The effects of certain histories of reinforcement can be persistent. For example, Urbain, Poling, Millam, and Thompson (1978) exposed one group of rats to a fixed-ratio (FR) 40 schedule and a second group to an interresponse time (IRT) > 11-s schedule, followed by exposing both groups to a fixed-interval (FI) 15-s schedule. The rats with the FR history continued to respond at a high rate on the FI schedule, whereas the rats with the IRT > 11-s history continued to respond at a low rate; this differential responding persisted across 93 sessions of exposure to an FI schedule. Freeman and Lattal (1992, Experiment 1) also found persistent high- and low-rate responding by pigeons across 60 sessions of exposure to an FI schedule following high- and low-rate training.

Some evidence indicates that a history of low response rates has unique effects upon subsequent responding. Johnson, Bickel, Higgins, and Morris (1991) investigated response rates under an FI food-reinforcement schedule as a function of two events: previous high- or low-rate training under schedules of food reinforcement and the availability of drinking water. During the first phase of the experiment, water was continuously available. Two rats were exposed to an IRT > 11-s schedule, and 2 other rats were exposed to an FR 40 schedule of reinforcement; all 4 rats were then exposed to an FI 15-s schedule. In the second phase of the experiment, the amount of available water was manipulated during the FI schedule. For rats with the FR history, responding stayed the same regardless of the amount of water available. For rats with the IRT > 11-s history, however, responding increased as the amount of water available decreased. In a series of studies with human subjects, Weiner (1969) investigated a conditioning history that included exposure to both differential-reinforcement-of-low-rate (DRL) and FR schedules of reinforcement prior to exposure to an FI schedule. For most subjects, responding on the FI schedule resembled that on the DRL schedule, even though high rates of responding

Correspondence and requests for reprints should be sent to Janet R. LeFrancois, Psychology Department, Converse College, Spartanburg, South Carolina 29302-0006.

had been conditioned during the intervening FR schedule.

The enduring effect of exposure to low-rate conditioning is especially intriguing in that it seems contradictory to Sidman's (1960) characterization of history effects as a transition state, implying that past contingencies exert transient control over current behavior. Freeman and Lattal (1992) concur that "the perseverative influence of past reinforcement contingencies at the expense of control by current ones . . . would be counter to the malleability of behavior and its adaptability to the present environment" (p. 13). In this light, Weiner's (1969) assertion that "histories such as DRL may determine final FI performance despite the fact that they are in the remote past, and quite different rates and patterns of responding have been effected by intervening histories" (p. 370) warrants further attention. Thus the purpose of the present research was to investigate the control of a low-rate history over subsequent FI responding in laboratory animals. Specifically, one group of rats was exposed to a DRL schedule followed by conditioning on an FI schedule, and a second group of rats was exposed to the same conditions but with an FR schedule interposed between the DRL and FI schedules.

## METHOD

### *Subjects*

Six adult albino rats, maintained at 80% of their free-feeding weights, served as subjects. Three of the subjects had previously served in a class demonstration of a light–dark discrimination in which the light cued an FR 10 schedule and the dark cued extinction; the other 3 subjects were experimentally naive.

### *Apparatus*

An operant conditioning chamber (Lehigh Valley Electronics 1578), measuring 25.5 cm by 25.5 cm by 23.4 cm, was used. The front panel included a response lever measuring 2.5 cm by 1.5 cm by 0.75 cm. It was located 3 cm from the right wall of the chamber and 3 cm from the floor of the chamber. A 28-V cue light (GE 1819) was located 3 cm from the right wall of the chamber and 3.5 cm above the response lever. Access to each 0.45-g Noyes food pellet was through an aperture (7 cm by 5.5 cm) positioned 2 cm from the floor and 7 cm from the right wall of the chamber. A one-way mirror (12.5 cm by 7.5 cm) was located on the back wall, 7.5 cm below the ceiling. On the ceiling were located a 125-V houselight (7.5 W) and a speaker that introduced white noise into the chamber. The chamber was enclosed in a light- and sound-attenuating box (LVE 1642). The chamber was wired to electromechanical programming equipment and to a cumulative recorder.

### *Procedure*

The naive subjects were trained to eat from the magazine, and bar-press responses were shaped by reinforcement of successive approximations. Then, all subjects were exposed to the experimental conditions as presented in Table 1. Each condition continued for a minimum of 15 sessions, each 25 min long. Then, responding was judged to be stable under the following regulation: During six consecutive sessions, the mean number of reinforcers earned per session in the first and the last three sessions had to fall within $\pm 5\%$ of the six-session mean (cf. Schoenfeld, Cumming, & Hearst, 1956). The condition remained in effect until stability was met. Each subject was exposed first to the DRL schedule, which began with a low DRL value and was gradually increased until DRL 20-s responding was acquired. This schedule was in effect until the number of reinforcers earned per session stabilized. Next, Subjects 7, 10, and 15 were exposed to an FI schedule, the specific value of which was based on the average number of reinforcers earned per session during DRL stability for that subject. This was done to maintain a constant reinforcement frequency from DRL to FI conditioning. The FI condition was in effect for at least 15 sessions and until both the frequency of reinforcers and the frequency of responses per session had stabilized. The response-frequency stability measure was made in this condition because response frequency can vary widely without affecting reinforcer frequency under an FI schedule.

Subjects 11, 13, and 14 were exposed to an FR schedule following DRL 20-s training. Initially, the value of the FR schedule was low and then was increased gradually to a value, not higher than 40, that would maintain high response rates. The FR condition ended when reinforcer earnings stabilized. Subjects 11, 13, and 14 were then exposed to an FI schedule,

Table 1

Order of conditions, schedule values, and number of sessions per condition for each subject.

| Subject | Condition 1 | Condition 2 | Condition 3 |
|---|---|---|---|
| 7[a] | DRL 20 s (58) | FI 52 s (15) | |
| 10[a] | DRL 20 s (67) | FI 33 s (23) | |
| 15 | DRL 20 s (51) | FI 43 s (27) | |
| 11[a] | DRL 20 s (40) | FR 20 (53) | FI 34 s (15) |
| 13 | DRL 20 s (62) | FR 15 (78) | FI 52 s (15) |
| 14 | DRL 20 s (54) | FR 30 (85) | FI 43 s (16) |

[a] Experimentally naive.

the value of which was based on the average number of reinforcers earned during both the previous DRL and FR conditions. Both conditions were represented in this calculation so that the reinforcement frequency of the final FI would be consistent with all preceding conditions. The subjects were exposed to the FI schedule until responding and reinforcer frequency had stabilized.

## RESULTS

As indicated in Table 1, every subject completed each condition, typically requiring more sessions to reach stability under the DRL and FR conditions than under the FI conditions. Further, all subjects acquired low-rate bar pressing under the DRL schedule, as can be seen in the representative cumulative records in Figures 1 and 2. Maximally efficient responding under a DRL 20-s schedule would be one response every 20 s (or three responses per minute). In Figures 3 and 4, the numbers of responses per minute during stability sessions of the DRL and FR conditions are graphed. In the DRL condition, every subject approximated three responses per minute.

Subjects 7, 10, and 15 were then exposed to the FI schedule, and, as indicated in the cumulative records of Figure 1, the slope of the FI record was slightly steeper and rudiments of scalloped patterns were more frequent than during DRL conditioning. The number of responses per minute increased very slightly from DRL to FI for all 3 subjects (Figure 3).

Subjects 11, 13, and 14 were exposed to the FR condition after DRL training. The cumulative records of Figure 2 and the response-rate graphs in Figure 4 indicate an increase in response rate from DRL to the FR condition. The FR response pattern for Subject 13 was atypical, in that a few long pauses occurred during most FR sessions. Even though this subject was exposed to the FR condition for 78 sessions, the pausing did not cease. Finally, these subjects were exposed to the FI condition. In the cumulative records of Figure 2, the slope of FI responding resembled FR responding more than it resembled DRL responding for all subjects. However, there were more pauses in responding and rudiments of scalloped patterns during FI conditions for all subjects. Subject 14 showed the greatest overall decrease in responding from FR to FI (Figure 4). However, response rates during the FI for

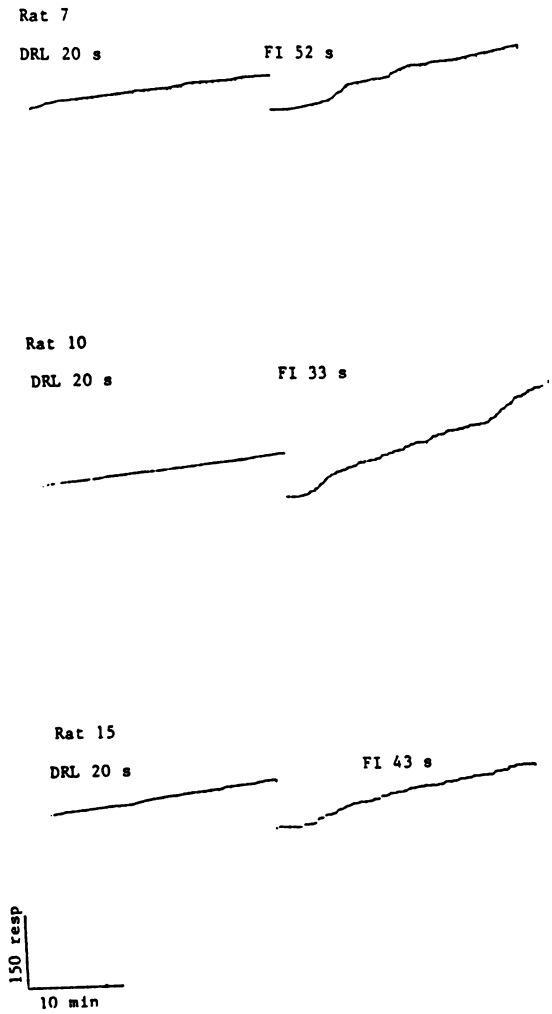


Fig. 1. Cumulative records of lever pressing in the final session in each condition for each subject in the DRL-FI condition.

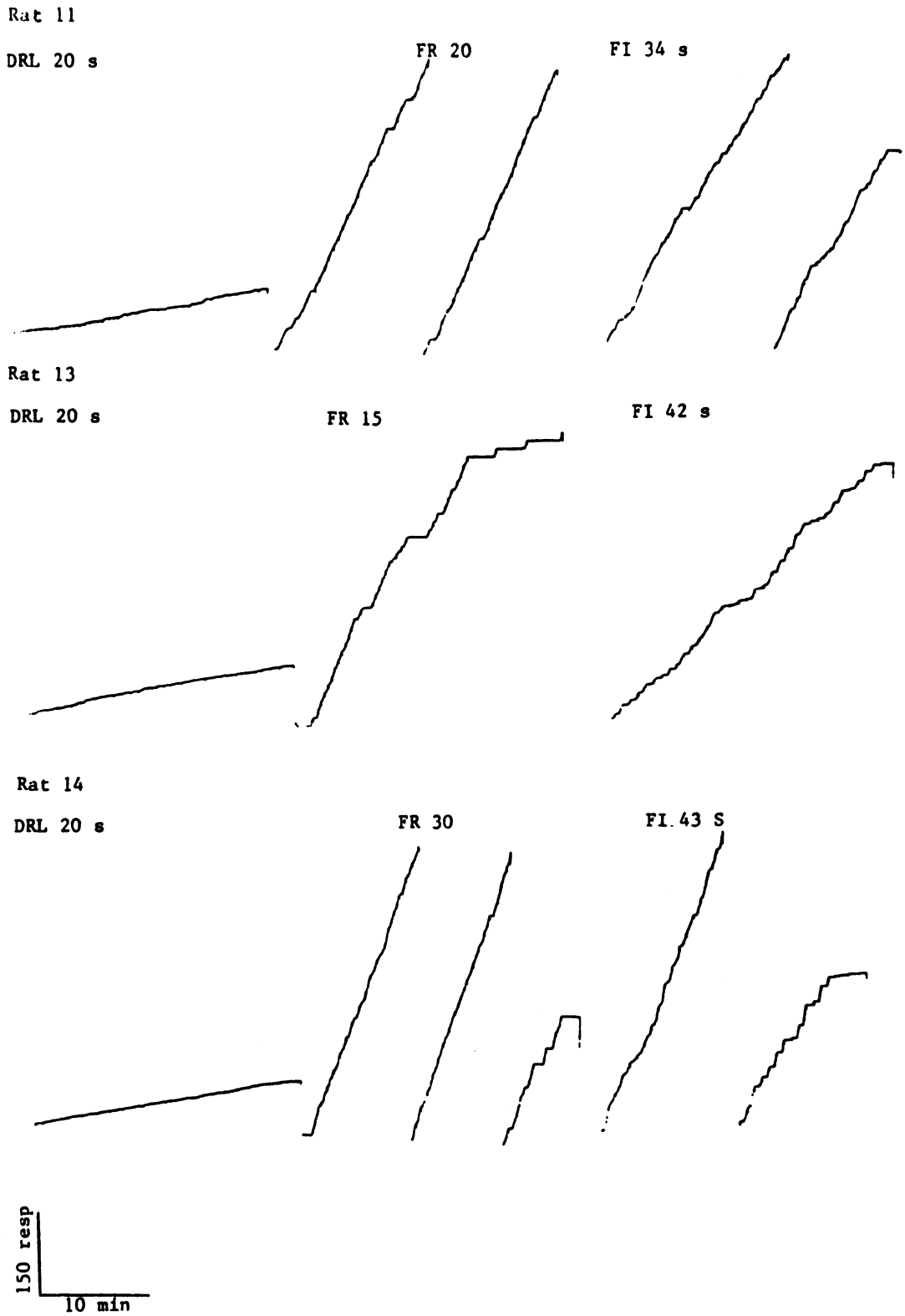


Fig. 2. Cumulative records of lever pressing in the final session in each condition for each subject in the DRL-FR-FI condition.

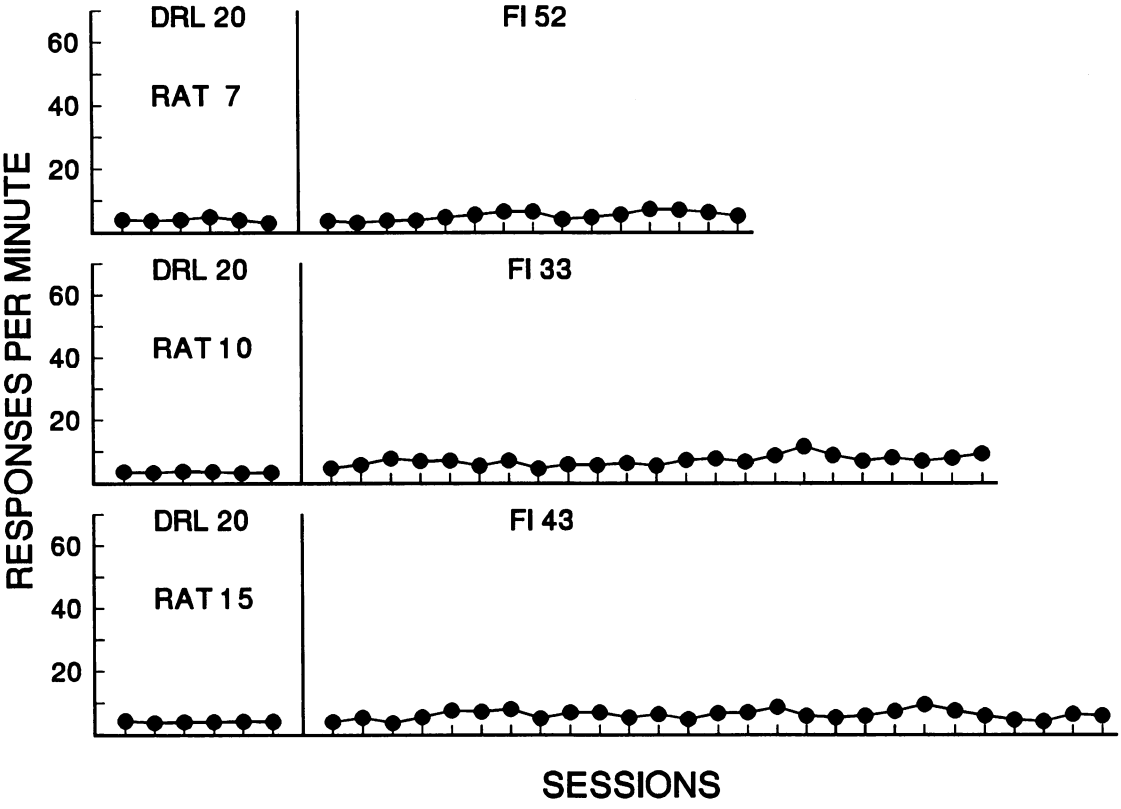


Fig. 3. Average number of responses per minute during each session of stability for the DRL condition and during every session of the FI condition for each subject in the DRL-FI condition.

this subject still were substantially higher than those during DRL.

In order to quantify the change in response rate from DRL to FI, measures of percentage change were calculated for each subject. Specifically, the difference between the average response rate during FI was taken as a percentage of the average response rate during stability sessions of DRL. For subjects exposed to DRL and then to FI, response rates increased by 56% for Subject 7, 134% for Subject 10, and 43% for Subject 15. This contrasts with measures of percentage change from DRL to FI for those subjects exposed to DRL, FR, and FI schedules. These changes are 851% for Subject 11, 356% for Subject 13, and 709% for Subject 14. When percentage change from FR to FI was calculated, smaller changes were found: −15% for Subject 11, −29% for Subject 13 and −45% for Subject 14.

## DISCUSSION

The findings of the present study indicate that low-rate conditioning was followed immediately by relatively low rates of FI responding. When higher rate conditioning intervened between low-rate and FI conditioning, relatively high FI rates were produced. These findings were consistent across subjects and were not differentially affected by the limited experimental history of 3 of the subjects.

Low-rate responding under an FI contingency following DRL training and higher FI response rates following FR training, as seen in the present study, are well substantiated in the literature (Freeman & Lattal, 1992; Urbain et al., 1978; Weiner, 1969). In the present study, the FI schedule was in effect for a minimum of 15 sessions, which might seem to be a limited opportunity for the FI contingency to affect responding. However in the DRL-FI condition, FI response rates increased slightly prior to stabilizing, which possibly indicates an effect of the FI contingency. Urbain et al. (1978) noted a similar increase in FI responding after low-rate training. Further, they noted that this increase never exceeded FI response rates that followed high-rate training and that the increase virtually ceased by the 15th ses-

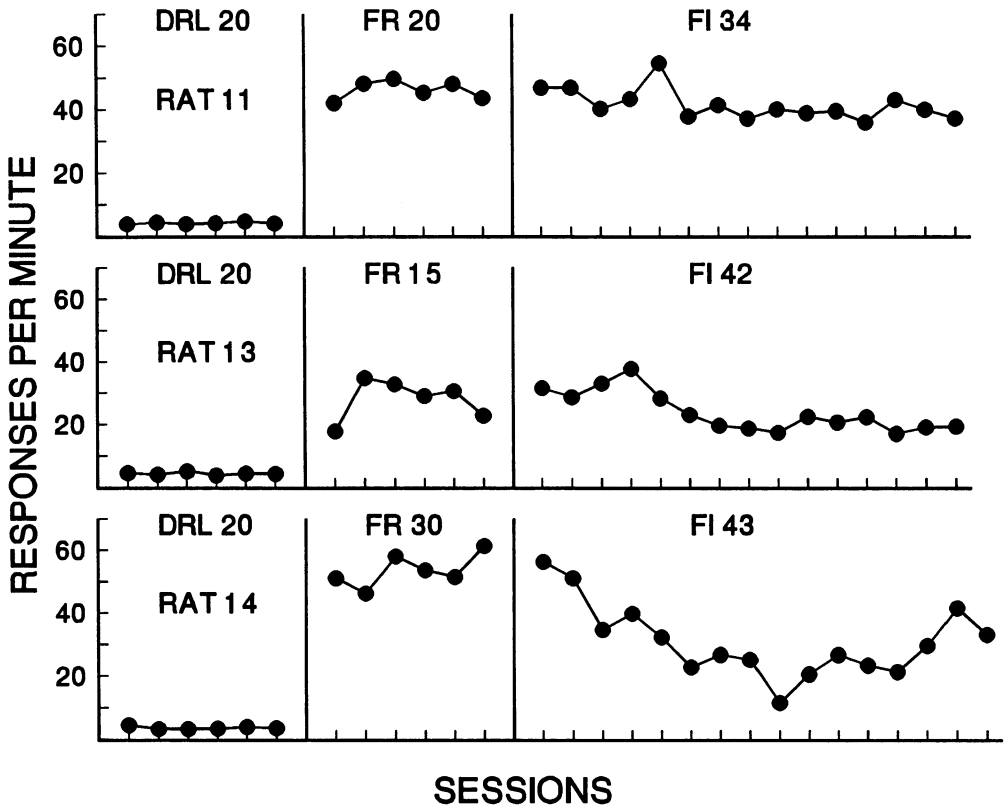


Fig. 4. Average number of responses per minute during each session of stability for the DRL and FR conditions and during every session of the FI condition for each subject in the DRL-FR-FI condition.

sion, not changing through the 93 sessions of the study. Hence, the slight increase in FI responding after DRL training that later stabilized in the present study more than likely would not have increased further with prolonged exposure to the FI schedule.

The remote DRL conditioning history was found to have minimal effect upon subsequent FI responding in the present study, although this cannot be said with certainty because no subjects were exposed only to FR before FI. This is inconsistent with findings from similar research with humans who responded at a low rate in the FI condition after conditioning under DRL followed by FR schedules (Weiner, 1969). Possible explanations for the discrepant findings are procedural differences (e.g., method of response acquisition or type of reinforcer) as well as differences in preexperimental histories and verbal behavior of nonhumans and humans. Other reasons for the lack of control exerted by the remote DRL condition over FI responding include the fact that during the intervening FR condition, low-rate responding produced few if any reinforcers, and thus was weakened if not extinguished. Second, during the FI condition, there were no discriminative stimuli to occasion low-rate responding. Freeman and Lattal (1992) indicated that if a remote history is brought under stimulus control, when the stimulus is affected, current responding can be controlled by past contingencies. Finally, it is possible that the DRL history had obscure effects upon responding under the subsequent FI schedule. Wanchisen (1991)[1] has argued that obscure history effects can be unmasked through certain procedures (e.g., the introduction of a drug). Perhaps measures other than FI responding would detect DRL history effects. At

[1] Wanchisen, B. A. (1991). *Unearthing the past: The future of behavior analysis and the link to Freud and other domains in psychology.* Manuscript submitted for publication.

the very least, the present findings call into question the assertion by Weiner (1969) that a DRL history is sufficient for low-rate responding.

From a slightly different perspective, the present findings underscore the influence of immediately prior conditioning over current responding. This is supported not only by the present findings for animals exposed to DRL followed by FI schedules but also by the data of the group exposed to DRL-FR-FI schedules. For these animals, acquisition of FR responding was prolonged, and pausing at times other than the postreinforcement pause was common. These findings suggest that a DRL history affected responding of the immediately subsequent FR condition. Also, FI responding for these animals occurred at a rate that was more similar to stable responding of the immediately preceding FR condition than to the more remote DRL condition, again suggesting that immediate history exerts more control than remote history. Research concerning delay of reinforcement suggests that a delay between a response and its contingent reinforcer or between a conditioned and an unconditioned stimulus weakens behavior relative to immediate reinforcement (LeFrancois & Lattal, 1987; Sizemore & Lattal, 1978). In the present study, it is possible that the remote DRL condition exerted minimal control over FI responding due to the delay between the two conditions.

An exception to the apparent control exerted by an immediate history over responding is the outcome of a study by Metzger and Lattal (1991). In this study, key pecking of pigeons was minimally affected by an immediate history of response acquisition with delayed reinforcement. That is, there was little or no difference in subsequent response rates or patterns between these birds and those whose responding was acquired under immediate reinforcement.

The discrepancy between the findings of Metzger and Lattal (1991) and studies that have found control by immediate history prompts further questioning of variables that determine the effectiveness and persistence of some conditioning histories. Possibly, the degree to which a conditioning history influences and continues to influence responding under a new contingency depends upon the similarity between the historical and current contingencies. Further investigation should assess this possibility.

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